Name______________________________ Class__________________ Date ______________

Summary

17–1 The Fossil Record

Fossils are preserved traces and remains of ancient life. Scientists who study fossils are called paleontologists. They use fossils to infer what past life-forms were like. All the information about past life provided by fossils is called the fossil record. The fossil record shows how life has changed over time. It shows that more than 99 percent of all species that ever lived on Earth have become extinct, or died out.

Few organisms are actually preserved as fossils. Most fossils that do form are found in sedimentary rock. As sediments build up in layers over time, they sometimes bury the remains of dead organisms. These dead organisms eventually turn into fossils.

Relative dating and radioactive dating are used to determine the age of fossils. Relative dating determines whether a fossil is older or younger than other fossils. It is based on where fossils are found in rock layers. Fossils from deeper rock layers are assumed to be older than fossils from rock layers closer to the surface. Index fossils represent species that lived for a short period of time but over a wide geographic range. Index fossils can help determine the relative age of fossils from different places. Radioactive dating determines a fossil's age in years. Radioactive elements in fossils decay, or break down, at a steady rate, called a half-life. A half-life is the length of time needed for half of the radioactive atoms in a sample to decay. A fossil's age is calculated from the half-life and the amount of remaining radioactive atoms the fossil contains.

The geologic time scale is used for evolutionary time. The scale begins with Precambrian Time. Following Precambrian Time, the scale is divided into three eras: the Paleozoic, Mesozoic, and Cenozoic eras. Each era is further divided into smaller lengths of time, called periods.

17–2 Earth's Early History

Earth is about 4.6 billion years old. At first, Earth was very hot and the atmosphere contained toxic gases. The atmosphere also contained water vapor but no oxygen. About 3.8 billion years ago, Earth's surface cooled and water vapor condensed. Thunderstorms soaked the surface, and oceans formed.

In the 1950s, Stanley Miller and Harold Urey simulated conditions on early Earth. They filled a container with water and gases found in Earth's early atmosphere. They passed electric sparks through the mixture to simulate lightning. Soon, organic compounds formed. The experiment showed that molecules needed for life could have evolved under conditions on early Earth. Sometimes large organic molecules form tiny bubbles called proteinoid microspheres. Structures similar to proteinoid microspheres might have become the first living cells. RNA and DNA also could have evolved from simple organic molecules.

The first known life-forms evolved about 3.5 billion years ago. They were single celled and looked like modern bacteria. Some were preserved as microscopic fossils, or microfossils. Eventually, photosynthetic bacteria became common. During photosynthesis, the bacteria produced oxygen. The oxygen accumulated in the atmosphere. The rise of oxygen drove some life-forms to extinction. At the same time, other life-forms evolved that depended on oxygen.

The first eukaryotes, or organisms with nuclei, evolved about 2 billion years ago. One explanation for how eukaryotes evolved is the endosymbiotic theory. This theory proposes that smaller prokaryotes began living inside larger cells and evolved a symbiotic relationship with the larger cells.

Later, sexual reproduction evolved. Sexual reproduction increased genetic variation, so evolution could occur more quickly.

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17–3 Evolution of Multicellular Life

During Precambrian Time, life arose and evolved into multicellular forms. However, life still existed only in the oceans. Few fossils exist from the Precambrian, because the animals did not yet have any hard parts.

There is much more fossil evidence from the Paleozoic Era. Animals with hard parts, such as trilobites, evolved then. Other important evolutionary events of the Paleozoic include the evolution of land plants, insects, amphibians, and reptiles. At the end of the Paleozoic, there was a mass extinction, in which many types of organisms became extinct at once.

Important evolutionary events in the Mesozoic Era include the appearance of flowering plants and the dominance of dinosaurs. Reptiles, in general, were so successful during the era that the Mesozoic is called the Age of Reptiles. At the close of the Mesozoic, another mass extinction occurred.

The Cenozoic Era is called the Age of Mammals. During the Cenozoic, mammals evolved adaptations that allowed them to live on land, in water, and in air. The first humans fossils may have appeared about 200,000 years ago in Africa.

17–4 Patterns of Evolution

Macroevolution means large-scale evolution, or evolution above the level of the species. Six patterns of macroevolution are extinction, adaptive radiation, convergent evolution, coevolution, punctuated equilibrium, and changes in developmental genes.

Most of the time, extinctions have occurred because species could not compete for resources or adapt to gradually changing environments. Several times, however, mass extinction have occurred. During these mass extinctions, huge numbers of species became extinct at once. This may have occurred because of a combination of events, such as volcanoes erupting and asteroids striking Earth.

Adaptive radiation is the process in which a single species evolves into diverse species that live in different ways. Convergent evolution is the process in which unrelated species come to look alike because they have evolved similar adaptations to similar environments. Coevolution is the process by which two species evolve in response to changes in each other over time. For example, plants evolved poisons that protected them from insects. In response, insects evolved ways of protecting themselves from the poisons.

Darwin thought evolution occurred slowly and gradually. The fossil record sometimes shows a different pattern of evolution, called punctuated equilibrium. In this pattern, long periods of little or no change are interrupted by short periods of rapid change.

Some genes, called hox genes, control the actions of many other genes. Small changes in hox genes can produce major differences in adult organisms. Some scientists think that changes in hox genes may contribute to major evolutionary changes.